Minnesota Pollution Control Agency

Environmental Outcomes Division

Ground Water Monitoring & Assessment Program

Barium, Beryllium, Calcium, Magnesium and Strontium in Minnesota's Ground Water

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What are barium, beryllium, calcium, magnesium and strontium?

Barium, beryllium, calcium, magnesium and strontium belong to a group of chemicals called the "alkaline earth metals." Although these chemicals belong to the same chemical group, they vary widely in their abundance and behavior in ground water and in their potential health effects.

What are sources of barium, beryllium, calcium, magnesium and strontium in ground water?

Calcium and magnesium are abundant in rocks and soil, particularly limestones and dolomites. They are relatively soluble.

Strontium and barium are also abundant in earth materials, although their concentrations are one to two orders of magnitude lower than those of calcium and magnesium. Strontium and barium are less soluble than calcium and magnesium, but are found in appreciable quantities in aquifers consisting of sandstone and igneous rocks.

Beryllium concentrations in rocks are low. Beryllium is less soluble than the other alkaline earth metals.

Although they are used widely for industrial applications, there are no major anthropogenic (human) sources for these chemicals.

What are considered safe levels of barium, beryllium, calcium, magnesium and strontium in ground water?

Calcium and magnesium do not have drinking water criteria. Currently, there are no health concerns associated with these chemicals. However, calcium and magnesium may cause scaling of pipes. As a very rough approximation, concentrations of calcium plus magnesium greater than 100 mg/L (parts per million) are classified as "hard."

The Minnesota Department of Health (MDH) established health risk limits (HRLs) of 2.0, 4.0 and 0.00008 mg/L for barium, strontium and beryllium, respectively. A HRL is the concentration of a contaminant in ground water that is safe to ingest daily over a lifetime. The HRL for barium considers effects on the cardiovascular system in animal studies. The HRL for strontium considers the bone system, while the end point for beryllium is cancer.

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How are barium, beryllium, calcium, magnesium and strontium distributed in Minnesota ground water?

There were 22 exceedances of the HRL for beryllium and one exceedance for barium in wells sampled from the Ground Water Monitoring and Assessment Program (GWMAP) statewide baseline network of 954 wells. There was no exceedance for strontium. Calcium and magnesium do not have drinking water standards. The median concentrations of barium, beryllium, calcium, magnesium and strontium in all aquifers were 0.058, less than 0.000010, 76, 27 and 0.19 mg/L, respectively. Concentrations varied with the aquifer. While concentrations of calcium, magnesium and strontium were high in the Cretaceous aquifer, barium concentrations were low. Concentrations of barium, calcium and magnesium were low in the Precambrian aquifers, while beryllium concentrations were high. Concentrations of beryllium, calcium and magnesium were similar in Quaternary and Paleozoic bedrock aquifers, but concentrations of barium and strontium differed. Barium concentrations were highest in the Galena aquifer and low in the Jordan aquifer. Concentrations of strontium were high in the buried Quaternary and Galena aquifers and low in the Prairie du Chien and Jordan aquifers. Results indicate wide variability in the distribution of these chemicals in ground water; geology appears to be the controlling factor.

Which aquifers are most sensitive to contamination with barium, beryllium, calcium, magnesium and strontium?

Since the concentration of these chemicals in an aquifer is a function of geology, aquifer sensitivity is a function of geology and ground water residence time. As residence time increases, concentrations of these chemicals increase. Beryllium represents the chemical of greatest concern. Precambrian aquifers, especially the North Shore Volcanics, have high beryllium concentrations. Cretaceous and some buried Quaternary aquifers have very high concentrations of calcium and magnesium, which may lead to scaling of pipes. Anthropogenic inputs of these chemicals are small and essentially insignificant.

Why is it important to measure barium, beryllium, calcium, magnesium and strontium concentrations in ground water?

Calcium and magnesium are important ions in ground water and should always be sampled to assess quality control of samples and laboratory analysis. Barium, beryllium and strontium occasionally occur at concentrations near or above the drinking water criteria. They should be sampled in aquifers where these elevated concentrations occur.

What are some management strategies for reducing risks from barium, beryllium, calcium, magnesium and strontium?

Boiling may remove some of the hardness from water, but in very hard waters, artificial softening is the only mechanism for removing hardness.

Beryllium is the only alkaline earth metal that poses a potential health risk. Drilling wells in other aquifers may reduce risks from exposure to beryllium in certain aquifers.

Additional information, including reports and distribution maps, can be found on the Minnesota Pollution Control Agency's Web site at ***http://www.pca.state.mn.us/water/groundwater/gwmap/index.html***.